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FOREST BIOMASS ENERGY USE IN NEWFOUNDLAND

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FOREWORD

ENFOR is the acronym for the ENergy from the FORest (ENergie de la FORêt) program of the Canadian Forestry Service. This program of research and development is aimed at securing the knowledge and technical competence to facilitate in the medium to long term a greatly increased contribution from forest biomass to our nation's primary energy production. It is part of the federal government's efforts to promote the development and use of renewable energy as a means of reducing dependence on petroleum and other non-renewable energy sources.

The ENFOR program is concerned with the assessment and production of forest biomass with potential for energy conversion and deals with such forest-oriented subjects as inventory, harvesting technology, silviculture and environmental impacts. (Biomass Conversion, dealing with the technology of converting biomass to energy or fuels, is the responsibility of the Renewable Energy Division of the Department of Energy Mines and Resources). Most ENFOR projects, although developed by CFS scientists in the light of program objectives, are carried out under contract by forestry consultants and research specialists. Contractors are selected in accordance with science procurement tendering procedures of the Department of Supply and Services. For further information on the ENFOR Biomass Production program, contact ...

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1.0 INTRODUCTION

"BIOMASS" refers to materials composed largely of carbon, hydrogen and oxygen which have been produced through photosynthesis. Forest biomass exists as a subset of this overall category and can be broadly divided into the following categories:

- **Mill residue:** waste byproducts associated with the processing of forest materials (eg. bark, sawdust, shavings).

- **Logging residue:** residual materials remaining in the forest after harvesting (eg. weed trees, tops and branches).

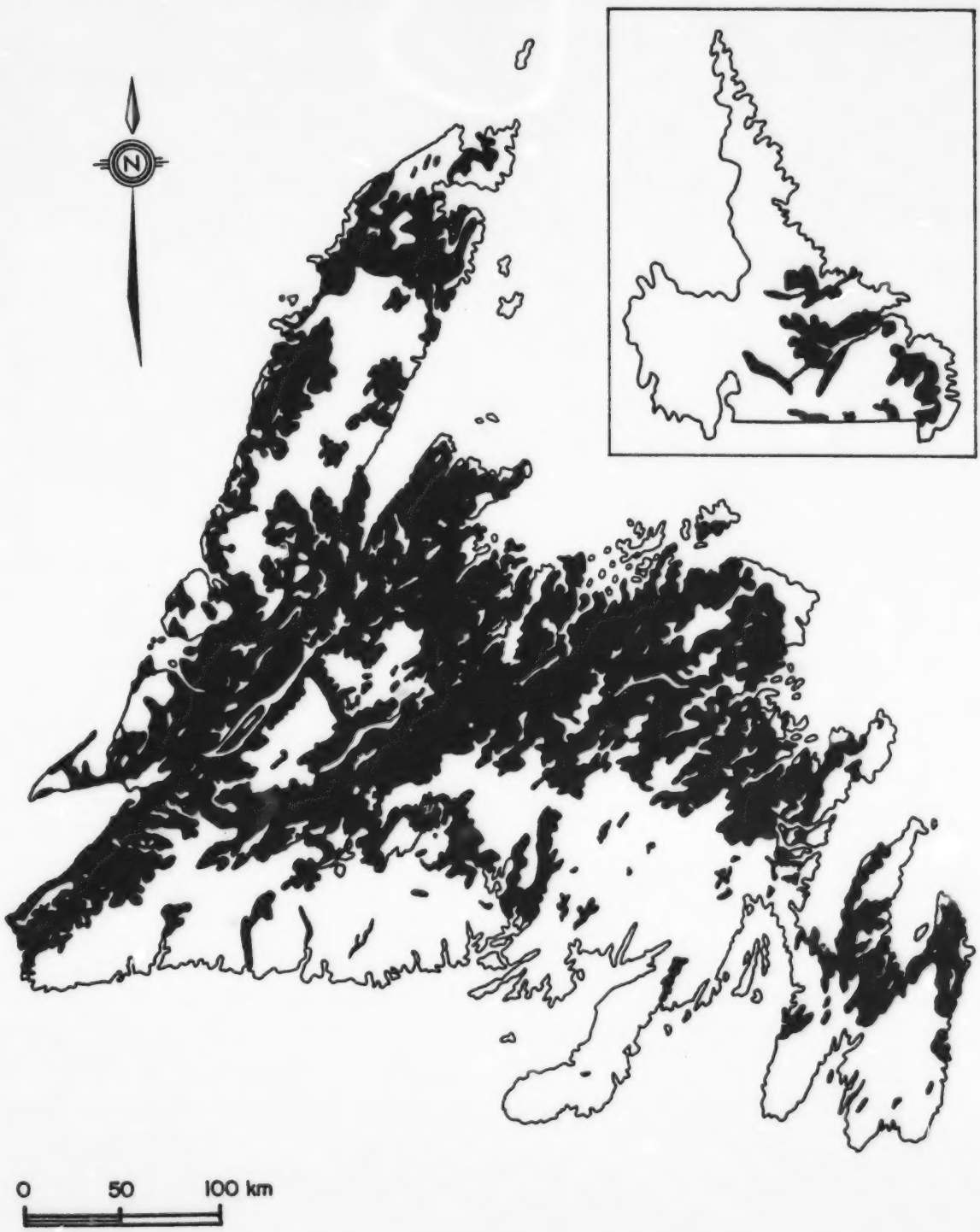
- **Salvage:** wood killed by fire, insects, disease, etc.

- **Merchantable surplus:** biomass over and above the industry demand for fibre for conventional forest products (Passmore and Ensyn, 1987).

Productive forest areas in the province (i.e. fibre yield over the rotation of not less than 35 m^3 per hectare) encompass 2.9 million hectares (Buggie, 1986), (Figure 1).

The global issue of alternate energy potential is one which readily beckons the involvement of several sectors of the provincial and national community. The Arab oil embargo and subsequent high oil prices of the 1970's, heightened interest in forest biomass as an energy source. In the past ten years the world oil price has seen considerable movement from $13.50 (1978) to a peak at $35.53 (1981) before returning to its

FIGURE 1
PRODUCTIVE FOREST AREA OF NEWFOUNDLAND



present level of $18.05 (U.S. $)[1]. Despite the uncertainty associated with the current oil price level, biomass fuels have remained the focus of directed research aimed at upgrading its appeal and potential benefit to prospective users in Newfoundland. Various initiatives (eg. harvesting trials, demonstration projects) have served to bring the resource to a further stage in its development.

The increased utilization of forest biomass for energy, particularly within the residential sector has spawned the emergence of a wide range of burning appliances (eg. woodstoves, wood/oil furnaces, etc.). Currently available from widely scattered home heating and hardware institutions, these units are fully certified by various regulating agencies (eg. Canadian Standards Association). The evolution of the "airtight" stove increased heating efficiency by controlling the amount of air entering the fire chamber. Two common types of heat transfer units are Radiant and Circulating. The former is the most popular type of stove which radiates heat from its hot cast iron or steel surfaces. The latter type draws cool room air into the space between two walls where it is heated and circulated back into the room (i.e. by natural convection or with a fan). These stoves are available in a wide range of heating capacities suitable to various settings and needs (eg. cookstoves, space heaters, mobile home units, etc.). Home heating is also possible through use of an array of wood fired furnaces including wood-oil and also wood-electric combination systems. Many units can be readily incorporated into an existing oil fired furnace unit to allow oil and wood burning (Ultramar Canada Incorporated, 1987).

1 Sources include World Oil Magazine, The Globe and Mail; 1978-1988.

The Newfoundland total net energy demand for petroleum products and electricity during 1986 was 76.88 Petajoules and 35.93 Petajoules respectively (Newfoundland Energy Review, 1987). These figures convert to a biomass equivalent of approximately 3,305,840 cords (6,611,680 tonnes) and 1,544,990 cords (3,089,980 tonnes) respectively (MC = 50%). Current biomass consumption has been estimated herein at 589,079 green tonnes (approximately 294,540 cords) based on information searches and interviews. The percent allocation for total provincial net energy demand is 64.3% - oil; 30.0% - electricity; 5.7% - wood. Natural gas is not presently available as an energy source in Newfoundland. This resource however, continues as a focus of offshore development; an estimated $660 million was expended on offshore oil and gas exploration during 1985 (Newfoundland Energy Review, 1985).

This project has been designed to provide a current update and information report pertaining to the present status of the biomass industry in Newfoundland. The work has required a review of available literature as well as direct interviews with numerous groups and individuals throughout the province (Appendix I).

This study was requested by the Canadian Forestry Service and is a joint effort on behalf of Northland Associates Limited as the prime contractor and D.W. Knight Associates Limited of St. John's.

The report is organized as follows: Chapter 2 presents a historical review of forest biomass utilization in this province; Chapter 3 provides a current estimate of biomass consumption within various participating sectors of the Newfoundland economy; An economic perspective of the forest biomass industry is provided in Chaper 4; Future opportunities and possible constraints regarding forest biomass are presented in Chapters 5 and 6 respectively; Conclusions are included in Chapter 7.

2.0 HISTORICAL REVIEW

2.1 Background

Forest biomass consumption for fuel in Newfoundland declined considerably during the 1950s and 1960s as more people moved to cleaner and more efficient oil and electricity for domestic heating and cooking purposes. Fossil fuels became more expensive with the OPEC oil crisis of the early 1970s. Since that time renewed interest has existed in forest biomass for fuel, firstly within the residential sector followed by public, commercial and forest industry sectors as oil prices continued to rise to a peak (mentioned earlier) in 1981.

The increase in price and decrease in consumption levels for two key conventional energy types in this province from the mid 1970s to the middle of this decade have been very significant (Table 1). The price increases are an obvious incentive for increased biomass consumption since the mid 1970s. Oil prices appear to have stabilized following the recent decline in price; however with everpresent tensions between the major international energy players (eg. OPEC vs. non-OPEC oil producing countries) forecasts for the future remain mixed.

Table 1. Residential energy prices and consumption changes from approximately 1974 - 1985*

Energy Source	Price Increase (%)	Consumption Decrease (%)
Electricity	217	24
Furnace Oil	249	35

* Newfoundland Statistics Agency, 1986.

2.2 Government Programs and Policies

Since the 1970s both the federal and provincial governments have maintained an active role in pursuing the goal of a viable forest biomass fuel industry in this province. The roles of the primary players involved (Energy, Mines and Resources Canada and Newfoundland Departments of Energy and Forestry) are presented here, followed by the Forest Industry, Commercial and Public Sectors.

2.2.1 Energy, Mines and Resources Canada (EMR)

Canadian government involvement in bioenergy development emerged in 1978. At that time, the federal government unveiled several incentive and support programs in conservation and renewable energy directed toward the industrial, commercial and residential sector (Passmore and Ensyn, 1987). In 1980 the National Energy Program (NEP) was announced by the Federal Government as a "commitment to support efforts by Canadians to work co-operatively towards Canada's energy goals." The NEP formed the foundation for a number of subsequent programs designed to reduce national dependance on imported oil. As well, the NEP has maintained and supported programs which were in operation prior to its inception (eg. Forest Industry Renewable Energy (FIRE) Program).

Energy programs sponsored by EMR and co-ordinated through the Provincial Department of Energy have helped advance the movement towards greater biomass utilization in this province. These programs are oulined in the following sections.

1. Conservation and Renewable Energy Demonstration Agreement (CREDA)

Signed in June 1979 by the Government of Canada and the Government of Newfoundland and Labrador, this $11.2 million cost-shared program (Federal 80%, Provincial 20%) was designed to demonstrate new technologies which utilize renewable energy resources or conserve energy. As well, this program focused on creating employment and providing an information transfer mechanism for educating the public on the benefits of new technologies. This program was administered by the Provincial Department of Energy and, before its expiration in 1985, was a major proponent of numerous renewable energy projects in this province. CREDA provided funding of $3.0 million for biomass projects in this province ($1.8 million - wood; $1.2 million - peat).

2. Energy from the Forest (ENFOR) Program

Initiated in 1978 and managed by the Canadian Forestry Service, Government of Canada, ENFOR was the country's first major forest research and development program. Its mandate included the generation of information and technology in various areas of biomass supply (eg. inventory, harvesting, transportation, etc.) and conversion with the aim of increasing the contribution of forest biomass to the national energy budget. This program sponsored some of the first woodchip harvesting trials in this province, conducted by Abitibi- Price from 1979 to 1981. Under the program $1.8 million have been spent in Newfoundland to date.

3. Canada Oil Substitution Program (COSP)

Established in 1980 under the NEP, this program was designed to encourage energy conservation and the adoption of alternate fuels (eg. wood). This program was instrumental in assisting the purchase of a plethora of domestic woodburning units (i.e. one time grant of up to $800.00 available) in this province before its expiration in 1985. The conservation component was especially effective in this province as homeowners moved to insulate and retrofit their residences. Grants totalling approximately $10 million were allocated in this province.

4. Forest Industry Renewable Energy (FIRE) Program

Initiated in the late 1970s and later expanded under the NEP, this was a program cost-shared up to 20% of the capital cost of conversion. This program was directed toward forest industries or any other organization interested in substituting wood residues for conventional fossil fuels. This program ended in March 31, 1986. (No Newfoundland projects received funding under this program.)

5. Remote Community Demonstration Program (RCDP)

Announced in 1982, this effort was designed to encourage and assist remote communities (i.e. those not connected or likely to be connected to an electrical grid or natural gas supply system) to identify and adopt oil substitution energy systems. This program is also open to private and public institutions (eg. utilities) having remote communities as part of their operations. The Roddickton wood-fired electrical

generating station is one such endeavour partially being funded by EMR under this initiative. RCDP is due to expire in 1989 and to date $1.15 million have been allocated in this province.

6. Class 34 - Tax Incentive Program

Introduced in 1976, this program provided an accelerated capital cost allowance against corporate income. The program objective was to encourage the business sector to increase its active involvement in areas of energy conservation and renewable energy by allowing a faster tax write-off of related equipment. Asset eligibility was expanded in 1979 to allow a greater diversity of equipment permitted consideration under this program. (This deduction was not claimed by any eligible parties in Newfoundland.)

7. Bioenergy Development Program

This program began in 1984 during the restructuring of the ENFOR program and has focused on the development of biomass conversion technology. This program is directed toward research organizations and provides financial support for innovative research, development and demonstration of new technologies. Due to expire in 1988, this program is involved in the identification of suitable projects which will advance the goal of greater biomass utilization within Canada's energy system. (Two peat related R & D projects have received funding of approximately $460,000.)

2.2.2. Newfoundland Department of Forestry (Forest Products Development Division)

This department was involved in the first whole tree chipping trial in Newfoundland in 1978. This experiment was a joint project by the department and the Abitibi-Price pulp and paper mill in Grand Falls. In the first year approximately 6,200 tonnes of biomass were harvested, chipped and used as a fuel supplement at the mill. These results proved encouraging and the project was continued in 1979 under ENFOR sponsorship. The results indicated that "at 1980 energy prices and using conventional harvesting methods, hardwood stands comprised of harvestable trees with a mean dbh of 10 cm or greater can be profitably utilized for energy purposes when located within 15 kilometres of a conversion centre" (Wilton and Duffett, 1980).

Since these early investigations, the Department of Forestry (under Forestry Subsidiary Agreements) has carried out several chipping trials in an effort to assist the establishment of an economically feasible fuelwood supply system in the province. These trials have included a range of chipper designs (eg. Morbark Eager Beaver, Bruks Offroad 800 and 1001 chippers) and forwarder combinations, meeting with varying degrees of success. Also, the results reflected the different stand and site conditions tested as well as distance to the burning facility. Such trials have provided an invaluable demonstration of available technologies to the woodfuel community of this province. Future activities by this department will concentrate more on integrated harvesting, for example sawlogs and woodchips in a single operation.

2.2.3 Newfoundland Department of Energy

As a leading advocate of greater forest biomass utilization for energy, this department has maintained a very active role in this regard in recent years. A primary area of involvement has been as administrator of the various CREDA projects carried out in this province. Examples include investigation in areas of fuelwood supply, chipping trials and residential chipburning. Biomass conversion projects under this program include the Gander Hospital (1983), Newfoundland Hardwoods Plant (1984) and Clarenville District Vocational School (1985).

A provincial study completed in 1985 (Potential Impact of Energy Conservation and Alternative Fuels in Newfoundland and Labrador, 1985-1995) estimated the required investment, and the impact of implementing the most promising biomass fuel projects, with simple payback averaging four years. Total investment required would be approximately $110 million resulting in fuel savings of approximately $30 million annually (based on 1985 oil prices) and generating 12,000 person years of employment over the life of the projects (Graham, 1985).

The department has recommended several prospective conversion projects for implementation. Some of these projects are nearly operational (eg. Central Newfoundland Regional Health Centre). Others, such as the Fishery Products International plants at Catalina and Harbour Breton, remain promising candidates for conversion.

A Memorandum of Understanding currently exists between the federal and provincial governments providing for the

expenditure of $2.9 million on various demonstration projects and information transfer activities. This agreement is due to expire on March 31, 1988. A new five-year cost-shared agreement between both levels of government is being proposed for 1988-1992. In addition, the Provincial Energy Department has outlined a six year alternate fuel program (1986-1992) to advance the development of an energy efficient infrastructure within the province. Provincial public sector buildings constitute one area of focus where improved energy utilization is the objective. Also, as indicated earlier, several private and public sector projects are recommended in an effort to reduce dependance on conventional fuel types.

During the early 1980s, alternate fuel types (especially woodfuel) had proven vital in decreasing the residential demand for oil and electricity. In 1983, woodfuel represented roughly 6% of total provincial energy demand and 25% of residential energy demand (Department of Mines and Energy, 1985). Government programs (eg. COSP) provided incentives for consumers to convert from oil to wood as a heat source. Subsequent program cancellations have removed such incentives but considerable latitude exists for continued oil substitution. Initiatives by both levels of government continue to encourage increased biomass utilization, for example financial assistance for new wood boiler installations, woodchip supply equipment and feasibility studies.

Federal government energy initiatives have undergone a transition as both the private and public sectors have become more involved in the woodfuel industry. Program emphasis has therefore been redirected from direct funding programs to less costly support of highly

selective and innovative operational demonstrations and information transfer. The level of demonstration project funding has been reduced as more energy conversion installations have been brought onstream.

Despite current low oil prices, the outlook appears promising for additional players in all sectors of the Newfoundland economy to move progressively toward greater biomass utilization and oil substitution. The combined roles of both levels of government is seen to be vital to the commercial adoption of attractive energy technologies (Provincial Consultants, 1986).

2.3 Historical Trends By Sector

2.3.1 Residential Sector

During the early 1970s, residential and commercial/ industrial sectors were faced with dependance on an increasingly non-economic fuel source. The more flexible residential sector began decreasing oil and electricity consumption and concentrated on greater utilization of forest biomass. Homes with some type of wood burning appliance began burning wood more intensively. As well, purchases of such appliances rose considerably. Prior to a study carried out by Northland Associates Ltd. (1984), little knowledge existed as to the actual level of wood consumption in the province, despite the general consensus of an overall increase in demand. Northland determined that the number of households burning wood increased from 22,000 before 1973 to approximately 32,000 in 1977-1978. Residential wood consumption for the latter period was estimated at 461,571 stacked m^3.

This consumption increased annually and levelled off in the early 1980s. This trend parallels a tapering-off of oil and electricity prices which have shown less dramatic year-to-year increases since that time. A further Northland study (1984) estimated island wide residential wood consumption at 820,004 m^3 solid, an increase of 168% over 1977/1978. Evidence of a real commitment to biomass utilization was seen in the number of households with wood or wood/oil furnaces increasing from 3-5% in 1978 to 18-20% in 1983.

2.3.2 Forest Industry Sector

Two forest companies, Abitibi-Price Inc. and Corner Brook Pulp and Paper Limited (formerly Bowater Newfoundland Limited) account for the large majority of commercial wood harvested in this province. With three newsprint mills in central and western Newfoundland, these companies occupy very prominent roles in both Newfoundland's forestry and economic environments.

Abitibi-Price Incorporated (Grand Falls)

As mentioned earlier, this company was a pioneer in the province's original whole-tree chipping trials during the late 1970s. The first undertaking in 1978 was a joint project between the company and the Provincial Department of Forest Resources and Lands. Favourable initial results prompted an extension of the trial into 1979 under ENFOR sponsorship. Objectives in 1979 included the development of operational techniques for harvesting under different stand conditions, and the assessment of site disturbance created by whole tree harvesting (ENFOR P-143). Results showed that whole-tree harvesting for hog fuel was economically and environmentally sound. ENFOR sponsored another series of trials in 1980-81; at this time the

emphasis was on integrated harvesting (i.e. pulpwood and sawlogs produced as well as hog fuel).

Similar harvesting methods were employed each year and consisted of transporting whole trees from the cutting site to a central landing where they were chipped by a Morbark Model 22 Chiparvester. The chips were then blown into modified dump trucks (and tractor trailers in 1980-81) and transported to the mill yard. In 1978, a Timberjack RW 30 Harvester was used as a feller forwarder and feller buncher in concert with wheeled skidders. Operations during the other years relied on manual felling and forwarding with wheeled skidders (ENFOR P-143).

Unforeseen difficulties, notably the exceptionally wet weather and ground conditions, resulted in high unit costs of biomass produced and an overall project net loss which "would have been profitable under normal operating conditions." These trials were recommended for continuation and subsequently supported as a CREDA cost-shared initiative in 1981. Abitibi-Price Ltd. contributed $1,011,390.00 and CREDA $136,900.00. Operations continued from 1981 to 1984 and saw the company experiment with a Hydro-Ax Model 411 B Feller-Buncher to help reduce chipper breakdown resulting from mud and debris on trees skidded to the landing. This measure provided certain cost savings, however these were not sufficient to justify the capital investment required for such a system. Another modification involved the installation at the mill of a chipvan dumper constructed by Morbark Industries Inc. of Winn., Michigan. This dumper allowed the employment of tractor-trailers in an attempt to reduce the delays associated with use of smaller dump trucks. While reduced costs were realized, chipper time spent waiting for a truck increased. Despite

this apparent drawback, the chipvan dumper was perceived as more efficient by operators involved (Highlands Contracting Limited, 1985). These recent trials reinforced the feasibility of utilizing pure birch stands as a source of woodchips and endorsed further investigation of integrated harvesting and improvement of all production rates for chip harvesting.

Bowater Newfoundland Limited (Corner Brook)

Bowater's involvement in chipping trials began in 1981 under ENFOR sponsorship and continued until 1983. During this period a total of 20,021 green tonnes of woodfuel were harvested and burned. The objectives of these trials paralleled those of Abitibi-Price with consideration given to western Newfoundland, recognizing a much different operational environment. In western Newfoundland "the terrain is much more hilly; the trees are generally larger in diameter; there are no extensive stands of pure hardwood; and the average hauling distance was four times longer" (Van Nostrand and Case, 1984). These differences prompted the utilization of two separate operating systems. System 1 involved the manual felling of hardwood residuals on previously logged sites. This fibre was transported via Timberjack Model 450 Skidders to a landing and chipped with a Morbark Model 22RXL Total Chipharvester. Chips were blown directly into containers mounted on pallet-type trucks for transport to the mill. Terrain conditions of steep roads and restricted landing area precluded the use of tractor-trailers and favored the lower capacity chipvans. System 2 was designed to sustain an integrated whole tree harvesting operation for pulpwood/fuelwood retrieval. A Koehring Feller-Forwarder, Model K3FF was employed to cut and deliver whole trees to roadside. A Hahn Short Wood Harvester then processed the trees, separating pulpwood

and residue for fuelwood. A Bruks chipper, Model 1000 CT chipped the softwood limbs and tops and then blew the chips into container trucks for transport to the mill.

As was experienced by Abitibi-Price Inc., integrated harvesting trials (System 2) did not prove cost effective. Production levels were well below those required to ensure a profitable undertaking. System 1 confirmed the feasibility of harvesting and burning hardwood chips from residual trees on pulpwood cutovers. These results prompted Bowater to continue burning woodchips at its facility up until the summer of 1985 when excessive levels of particulate emission at the mill forced the termination of the woodchip operation.

Abitibi-Price Incorporated (Stephenville)

Unlike the two previous newsprint mills, this west coast mill has not engaged in harvesting or chipping trials but has been contemplating a move to woodchip consumption based on the results of the aforementioned studies. For several years this mill has burned all its wet bark generated in newsprint production, to supplement its consumption of Bunker C oil. The combined effects of low oil prices and a perceived lack of a secure and sizeable fuelwood supply have served to dampen the prospects for committing the required capital outlay necessary to retrofit the plant for woodchip consumption.

2.3.3 Commercial Sector

The experience gained through both forest industry and government-based initiatives of the late 1970s and early 1980s provided a receptive environment for new participants in the provincial woodfuel industry. Ensuing private sector involvement has resulted in the creation

of a province-wide network of commercial woodburners. While a natural diversity of disciplines and scales of operation exists, the common objective has been to reduce dependance on oil and electricity with a corresponding decrease in energy costs.

Four businesses, John Lloyd Ltd. (Baie Verte), Natural Enterprises (Butts Pond), Adams Garage (Bishop Falls) and one other (Charlottletown) were fitted with Svemo woodburners as part of a CREDA initiative signed in 1981. This action provided each user with funding of three thousand dollars toward the cost of installation. The objectives of this project were to evaluate the practicality and cost-effectiveness of small scale wood burning operations (eg. equipment performance, harvesting and production appraisal) within the business community. Since the start-up, these businesses have maintained their use of woodfuel with a few modifications. Natural Enterprises were forced to modify their system to "get the bugs out," a process which required rebuilding parts of the unit. John Lloyd Limited curtailed its woodchip consumption due to a shortage of woodchips. Since then however, sawdust has become the primary fuel due to its surplus supply in the surrounding area.

Another unit was activated in 1982 under the CREDA program at Barony Produce in Cormack. This project involved the installation of a Hasha heating plant to service a commercial greenhouse. This system was operational in 1983 but technical problems and owner health problems precluded its continuation for a prolonged period. Despite this setback, the performance and heating capacity of the system impressed the owners who hope to reactivate it later this year.

Newfoundland Hardwoods Limited in Clarenville was the first medium scale private facility to sustain wood energy conversion activities in this province. This Northfab 300 hp system was operational in 1984 and continues today with relatively few technical and operational problems. This project was a CREDA initiative designed to demonstrate a cost-effective 3MW size wood boiler system and woodchip fuel supply operation (approximately 5000 tonnes/year). Newfoundland Hardwoods Limited at St. John's underwent a conversion to wood energy in 1987. This operation differs from the Clarenville outlet in terms of company size as well as fuel type required (i.e. St. John's outlet relies totally on wood waste generated internally rather than on woodchips from an independant supplier). This process illustrates a cost effective method of wood waste disposal while also reducing energy costs.

Additional small businesses which have installed wood burning units through to the middle of this decade include Wallken Enterprises (St. John's), Murphy's Transport (Corner Brook), Western Woodworkers (Deer Lake) and Wareham's Garage (Arnold's Cove). Each of these firms has continued to rely on wood as an energy source, with the exception of Murphy's Transport which curtailed its woodburning operation upon the sale of its office building in 1986. Plans are for possible reactivation of this unit in the near future.

Superior Logging (Springdale) commenced operations in 1987 as a producer of air and kiln dried wood products. Wood waste from its molding machine is the primary source of fuel for its 150 hp wood furnace. At a wood waste production rate of 6,364 kg per day and a 25% utilization rate, the potential exists for substantial gains in wood consumption as an energy source.

2.3.4 Public Sector

The installation of a Lamb-Cargate Wet Cell boiler-burner unit at the James Paton Memorial Hospital in 1983 heralded the province's first medium scale conversion initiative in the public sector. This project was a prototype as the first step toward the "ultimate goal of a province-wide wood fuel industry using wood waste and whole-tree chips to heat industrial and commercial buildings" (Shawmont Newfoundland Ltd., 1985). The original budget for this CREDA sponsored venture was estimated at $450,000.00 but after several revisions soon escalated to approximately $1 million. Project delays and cost overruns persisted during the design and construction phases of the project. A major contributing factor was the approach chosen by the project managers to specify system components and then rely on consulting engineers to create a workable system from various parts. A more cost efficient approach was taken by subsequent players such as Newfoundland Hardwoods Limited whereby a general specification of system requirements was prepared and equipment suppliers were invited to bid on a "supply and erect" package. This approach allowed for a more streamlined conversion operation while adequately fulfilling project objectives. Neverthless, the Gander hospital project is a proven success and was instrumental in laying the groundwork for the development of a fuelwood industry in this province.

In 1984, Acres International Limited was awarded a contract for design and project management for the installation of a wood fired heating unit at the Eastern Community College in Clarenville. A Northfab system was selected as the technology to be demonstrated and startup was in October, 1985. This system is 30 hp, one-half of the capacity of one of the two existing oil-fired units.

As expected, the oil unit routinely activates on very cold days to maintain the water temperature at the desired level. Records from August/86 to March/87, indicated that the oil unit was necessary for only 1.3% of the time (Acres International Limited, 1987). Most problems encountered in the startup stage were resolved. However, one persisting problem involves the chain-driven conveyor which feeds chips from the receiving bin to the main storage chamber. Chips frequently become wedged under the "fins" of the conveyor thus requiring constant supervision and correction during fuel delivery. A modification or component replacement would effectively remedy this problem.

Western Memorial Hospital at Corner Brook has a wood burning unit installed which commenced operation on February 22nd, 1988. Woodchip consumption is estimated at 10,000 tonnes per year and a ten year fuel supply has been assured by Corner Brook Pulp and Paper Company from leasehold property. Hospital management remains optimistic toward the potential benefits of their installation and looks forward to future developments. The hospital is presently investigating the possibility of burning waste bark from the Corner Brook Pulp and Paper mill.

The Central Newfoundland Regional Health Centre at Grand Falls is slated to commence wood burning operations during the fall of 1988. This facility will consume approximately 4,000 tonnes of woodchips per year from as yet, an undetermined source. The initial recommendation was for a 100 hp oil/wood fired unit but the final specification calls for a 140 hp unit in order to meet a higher percentage of the hospital's heat load.

2.4 Summary

The widespread expectations of oil shortages and accompanying price hikes of the early 1970s prompted a heightened interest in alternate fuels. Forest biomass, a traditional energy source in this province, was considered a likely alternative to fossil fuels and has undergone increased utilization since the 1970s. Despite oil price volatility, forest biomass continues as a source of fuel in Newfoundland. Federal and provincial government departments have encouraged greater involvement of all sectors in biomass utilization through a range of policy initiatives and programs. Since the last decade, several programs have proven successful in expanding the wood burning community of this province.

3.0 CURRENT USE OF FOREST BIOMASS

The current level of forest biomass consumed in Newfoundland (Table 2) was estimated by compiling information from both published sources, and a survey of non-residential users (Figure 2). These users include known government funded projects as well as non-subsidized endeavours surveyed for this study. Consumption estimates are presented on a volume (m^3) and weight (green tonne) basis. Two aforementioned businesses have been omitted in Table 2 (i.e. Barony Produce; Murphy's Transport) as each has suspended its woodburning operation until a later date. In addition, the Central Newfoundland Regional Health Center has not been included within the context of current consumption. As previously mentioned, this facility is due to be operational vis-a-vis woodburning later this year.

It is clearly beyond the scope of this report to conduct an in depth survey of residential biomass consumption throughout the province. The estimate of current residential biomass consumption, is based on previous studies in 1984 (Northland Associates Limited). These 1984 figures were adjusted directly proportional to the increase or decrease in domestic cutting permits issued (on an individual Management Unit basis) from that period up to 1986-87. This current figure (354,218 green tonnes) represents a decrease of 20% from 1984 estimates and partly reflects the waning appeal of forest biomass as oil prices decrease.

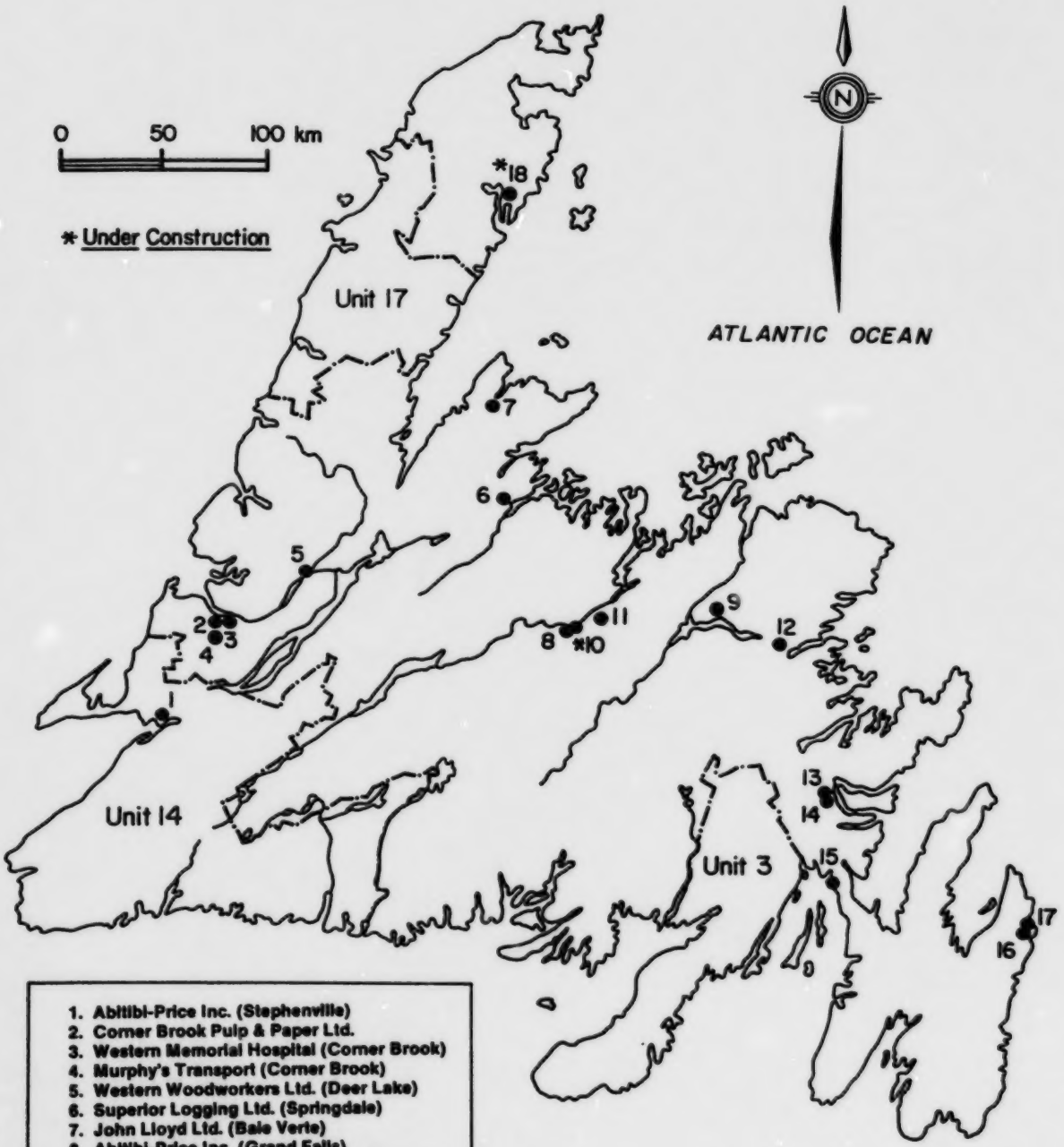
TABLE 2. Estimated current biomass consumption in Newfoundland

Sector	Facility	Annual Consumption (green tonnes)				
		Wood-chips	**Round-wood**	**Bark**	**Other**	**Total**
Forest Industry	Abitibi-Price Inc. (Grand Falls)	33,000		46,000		79,000
	Abitibi-Price Inc. (Stephenville)			70,000		70,000
	Corner Brook Pulp and Paper Ltd.			65,000		65,000
	Sub-total					**214,000**
Commercial	Nfld. Hardwoods Ltd. (Clarenville)	4,000				4,000
	Nfld. Hardwoods Ltd. (St. John's)				550*	550
	Wallken Enterprises Limited				63*	63
	Natural Enterprises Limited	25	3			28
	Kevin Wareham Ltd.				40**	40
	Adams Garage		125			125
	John Lloyd Ltd.				134*	134
	Superior Logging Ltd.				2,300*	2,300
	Western Woodworkers Limited				141*	141
	Sub-total					**7,381**
Public	James Paton Memorial Hospital	3,000				3,000
	Eastern Community College	480				480
	Western Memorial Hospital	10,000				10,000
	Sub-total					**13,480**
Residential						
	Sub-total		**354,218**			**354,218**
TOTAL WEIGHT (green tonnes)		**50,505**	**354,346**	**181,000**	**3,228**	**589,079**
TOTAL VOLUME (m^3)		**91,414**	**641,366**	**327,610**	**5,843**	**1,066,233**

* Wood waste generated from internal operations

** Wood waste procured from local sawmills

FIGURE 2
LOCATION OF NON-RESIDENTIAL BIOMASS USERS



1. Abitibi-Price Inc. (Stephenville)
2. Corner Brook Pulp & Paper Ltd.
3. Western Memorial Hospital (Corner Brook)
4. Murphy's Transport (Corner Brook)
5. Western Woodworkers Ltd. (Deer Lake)
6. Superior Logging Ltd. (Springdale)
7. John Lloyd Ltd. (Baie Verte)
8. Abitibi-Price Inc. (Grand Falls)
9. James Paton Memorial Hospital (Gander)
*10. Central Regional Hospital (Grand Falls)
11. Adams Garage (Bishops Falls)
12. Natural Enterprises Ltd. (Butts Pond)
13. Eastern Community College (Clarenville)
14. Nfld. Hardwoods Ltd. (Clarenville)
15. Kevin Wareham Ltd. (Arnold's Cove)
16. Nfld. Hardwoods Ltd. (St. John's)
17. Wallken Enterprises Ltd. (St. John's)
*18. Roddickton Electricity Generation

The total current biomass consumption (i.e. 1,066,233 m^3/yr) has resulted in an estimated furnace oil displacement of 175,208,589 liters. Furnace oil (#2) has been used here simply for purposes of uniformity.

Table 3 presents the mean unit cost and price range (where available) for various forest biomass types as obtained from interviews and literature reviews. Regional cost variation is difficult to evaluate since certain of the prices included herein do not reflect the cost of labor and equipment, etc. This is evident when biomass is self procured by the individual or institution involved.

Merchantable wood volume consumed as fuel in the residential sector during 1986-87 has been estimated by the Provincial Department of Forestry at 341,921 m^3 (194,273 green tonnes). This accounts for approximately 53% of the total forest biomass utilized by this sector within the province for the same period as indicated in Table 2.

Table 3. Forest biomass cost per tonne ($) as surveyed from previously indicated consumers.

Biomass Type	Maximum	Minimum	Mean
Woodchips	38.00	10.00	30.40
Roundwood	50.00	10.00	30.00
Bark	na	na	na
Other	22.38	12.50	17.44

na - Not Available

4.0 ECONOMIC IMPACT OF BIOMASS ENERGY USE

4.1 Purpose and Objectives

The displacement of foreign oil with forest biomass for energy generation in Newfoundland has an import substitution effect, resulting in the retention of income within the national economy and the creation of new jobs and incomes in the province. Depending on the price of oil, the major benefit to the users of biomass is the cost saving that can be realized as a result. These impacts take on greater importance by the fact that they are principally felt in rural communities where employment and business opportunities are generally fewer than in urban locations.

The purpose of this chapter is to examine the socio-economic benefits of biomass energy use in Newfoundland and determine the net contribution to the provincial economy. Specific objectives are to determine;

(1) existing savings realized by the conversion from fuel oil to forest biomass for energy production in industrial and institutional facilities,

(2) existing savings realized by the burning of fuelwood in the residential market, and

(3) net employment and income benefits within the province due to biomass energy use and residential woodfuel consumption. All activities will be assessed including the construction and operation of burning facilities plus the harvesting and delivery of the biomass fuel.

4.2 Savings Due to Biomass Use in Industrial-Scale Facilities

The feasibility of converting a facility from oil energy to forest biomass depends on the monetary savings that can be realized as a result. Three major factors influence these potential savings. The two most crucial factors are the

comparative costs of fuel oil and biomass, and the capital investment and corresponding financing costs of the conversion project. The other influencing factor is the ongoing cost of operation and maintenance of the facilities. The following discussion examines each of these factors individually.

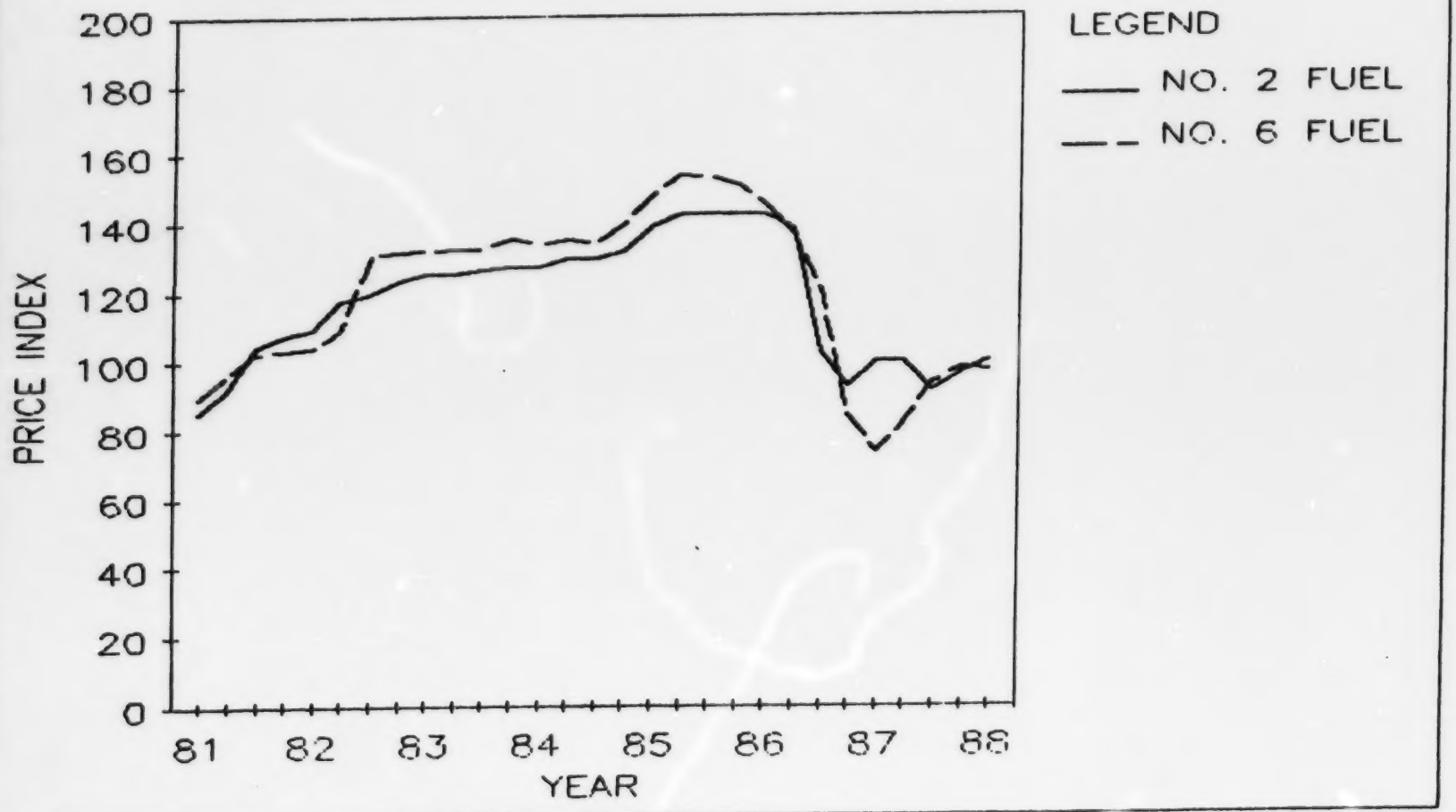
4.2.1 Energy Cost Savings

(a) Impact of Oil Prices

The price of oil and the price differential between oil and biomass are the crucial factors influencing the economic feasibility of converting oil-fired plants to biomass fuel. The higher the oil price, the higher the savings that can be realized by converting to biomass. With the eight-fold increase in oil prices from 1970 to 1980 (Industry Selling Price Index), conversion to biomass energy became substantially more viable. This shift in relative energy costs resulted in a number of conversion projects in institutional and industrial facilities within the province after 1980. Two more projects at the Grand Falls and Corner Brook Hospitals are currently under way. A number of others have gone through initial planning stages but are of uncertain status at this time.

Two petroleum products, No. 2 and No. 6 (light and heavy) fuel oil, are normally used in oil-fired plants in Newfoundland. Price levels continued a rising trend in the first half of the 1980s although at much slower rates than in the preceding decade (Figure 3). When prices peaked in 1985 they were 40 to 50 percent higher than 1981 levels. Prices started to decline in 1985 and suffered sharp drops in 1986. No. 2 fuel oil fell by approximately a third from its peak level in 1985 while

Figure 3 FUEL OIL PRICE INDEX
NO. 2 (Light) & NO. 6 (Heavy) FUEL OILS
ATLANTIC PROVINCES; 1981–87
1981 Average Price Index = 100



No. 6 fuel fell by more than half. As illustrated in Figure 3, both products have fluctuated at close to 1981 price levels for the past year or so.

A review of the literature and telephone interviews with a number of facilities confirmed the substantial drop in fuel oil prices since 1985. At that time the price was as high as 34 cents per liter for No. 2 fuel oil and 26 cents per liter for No. 6 fuel oil. Over the past year, industrial prices for No. 2 fuel have been in the range of 21 to 24 cents while No. 6 has been in range of 17 to 19 cents.

Predicting future oil price trends is a difficult task. Supply and demand conditions are highly influenced by global circumstances such as rates of economic growth, levels of investment in new resource supplies, and volatile political and economic climates in several major oil-exporting countries. Nevertheless, long-term expectations are that global demand will continue to increase and prices will take an upward trend as existing reserves dwindle and investment is required to bring new higher-cost reserves into production.

A recent publication by the Newfoundland Department of Energy assumes fuel oil price increases based on the general forecasted inflationary price index (Department of Mines and Energy, 1986). These escalation rates do not consider the particular circumstances of the petroleum industry. However, due to the uncertainties inherent in the oil market, the index is probably as good an indicator as is possible. The forecast increases are as follows: 2.8% from 1986-90; 4.0% from 1991-95; 4.5% from 1996-2000; and 5.3% percent after 2001.

(b) Oil Displacement Capacity of Biomass

In reviewing the various studies of existing and proposed wood-burning plants in Newfoundland, the fuel oil displacement capacity of biomass in these facilities appears to be fairly consistent in the range of 210 to 250 liters per tonne of biomass. Although the studies do not indicate in each instance whether it is No. 2 or No. 6 fuel that is being displaced, the displacement capacity for No. 6 fuel tends to be in the higher end of the range and for No. 2 fuel in the lower end of the range. The average displacement capacity as calculated from a random selection of these facilities was approximately 231 liters per tonne of biomass.

(c) Potential Savings on Fuel Purchases

Table 4 provides a summary of the oil-equivalent value of a tonne of forest biomass based on a range of prices for oil.

Table 4. Oil Equivalent Value of Biomass**

Price of Fuel Oil (Per Liter	Oil-Equivalent Value of (Per Tonne
35¢	$80.85
33¢	$76.23
31¢	$71.61
29¢	$66.99
27¢	$62.37
25¢	$57.75
23¢	$53.13
21¢	$48.51
19¢	$43.89
17¢	$39.27

Current delivered costs of biomass lie in the range of $28 - $40 per green tonne for puchased fuel chips, $25 - $26 per tonne for paper company-produced chips, and $22 - $24 for sawmill residue. Using the oil-equivalent values indicated in Table 4, Table 5 shows potential savings per tonne of burning biomass instead of oil based on a range of prices for biomass. An assumption is that the oil-displacement capacity of biomass remains constant at 231 liters per tonne.

** This assumes that 1 tonne of biomass has a fuel oil displacement capacity of 231 liters of oil and that this displacement capacity is the same for No. 2 and No. 6 fuel oil.

Table 5. Potential Fuel Savings in Converting from Oil to Biomass

Price of Fuel Oil Per Liter	Oil-Equivalent Value of Biomass (Per Tonne)	Delivered Cost of Biomass (Per Tonne)	Fuel Savings Potential of Biomass (Per Tonne)
35¢	$80.85	$20.00	$60.85
		25.00	55.85
		30.00	50.85
		35.00	45.85
		40.00	40.85
29¢	$66.99	$20.00	$46.99
		25.00	41.99
		30.00	36.99
		35.00	31.99
		40.00	26.99
23¢	$53.13	$20.00	$33.13
		25.00	28.13
		30.00	23.13
		35.00	18.13
		40.00	13.13
17¢	$39.27	$20.00	$19.27
		25.00	14.27
		30.00	9.27
		35.00	4.27
		40.00	(0.73)

As illustrated in Table 5 the full savings potential of converting from oil to biomass is highly dependent on the comparative costs of the two products. When fuel oil prices approached the 35 cents per liter level in 1985, the fuel savings potential ranged from $40.85 to $50.85

per tonne assuming costs of $30 to $40 per tonne for biomass. At current prices of approximately 23 cents per liter, the savings potential is substantially lower for similarly priced biomass, in the range of $13.13 to $23.13 per tonne.

For individual facilities, these price differences have a substantial impact on the savings potential of using biomass. For instance at the Gander Hospital, current annual biomass consumption is 3,000 tonnes at a contract price of $34.50 per tonne or an annual cost of $103,500. This volume of biomass displaces approximately 677,000 liters of fuel oil for a displacement capacity of 226 liters per tonne. At an oil price of 35 cents per liter the use of biomass would have resulted in an annual fuel saving of $133,450. At current prices in the 23 cents per liter range, the saving is much less, at about $52,210.

The fuel savings estimated above do not account for the extra capital costs or operation and maintenance costs involved in converting to biomass fuel. The following section examines the impact of these costs.

4.2.2 Impact of Extra Costs Associated with Conversion Projects

The direct savings realized in burning wood instead of fuel oil is negated somewhat by the capital and financing costs of converting to woodfuel and by extra operation and maintenance costs. The higher these costs are in relation to potential fuel savings, the lower the net benefit or savings will be.

(a) Capital Costs

Capital costs include all those associated with the initial installation and start-up of woodfuel facilities. Interest costs cover the opportunity costs of the capital investment or the actual borrowing costs if financed through debt.

A study by the Department of Energy (1986) showed that the economic viability of conversion projects is highly dependent on initial capital costs relative to the fuel savings they are able to generate. Sensitivity analyses carried out in the study showed an inverse, proportionately similar relationship between capital costs and the net present value of overall savings realized over the twenty-year lifespan of the facilities. For example, an increase in capital costs by $100,000 at the Gander Hospital facility resulted in a decrease in the net present value of savings by $99,500. Similarly, a capital cost decrease of $19,290 at the Clarenville Vocational School resulted in an increase in net present value by the same amount.

Another way the 1986 Mines and Energy study examined the impact of capital and interest costs on the savings potential of a facility was through the capital recovery schedule. This schedule subtracts the annual interest costs of the capital balance from the net cash flow savings realized from burning biomass to determine the annual recovery of capital investment. The number of years needed to recover the entire capital investment is called the "true payback period". The larger the cash flow surplus is, the shorter the true payback period will be and the higher total savings will be over the life of the facility.

Table 6 compares the projected true payback periods of a number of projects in the Department of Mines and Energy study in relation to their ratio of capital costs to estimated cash flow savings. Oil costs used to estimate fuel savings were based on actual prices paid by each plant in September, 1986 (Department of Energy, 1986). The table also presents the benefit/cost ratios based on the same input parameters.

Table 6. Impact of Capital Costs on Project Feasibility

Project	Ratio of Capital Costs to Estimated Cash Flow Savings*	Benefit/Cost	True Payback Period
Gander Hospital	12.9/1	0.87	NONE
NF. Hardwoods	4.1/1	2.75	4.9 years
Clarenville DVS	7.9/1	1.43	11.5 years
Corner Brook Hospital	6.9/1	1.65	9.5 years
Woodvale Nursery	6.1/1	1.86	8.1 years
Grand Falls Hospital	3.6/1	3.20	4.2 years
Stephenville District	11.4/1	1.00	NONE
F.P.I. Catalina	3.6/1	3.15	4.3 years
F.P.I. Harbour Breton	22.8/1	0.50	NONE

* The data used to derive these ratios are provided in Appendix II.

As illustrated by Table 6, the projects with the lowest capital costs in relation to fuel savings show the highest benefit/cost ratios and true payback periods.

When capital costs are high in relation to savings the cash flow surplus is largely lost in higher interest costs, resulting in low level of payback on capital costs.

(b) Operation and Maintenance Costs

The Department of Mines and Energy (1986) also provided estimates of extra operation and maintenance costs in individual facilities associated with the conversion to woodfuel. In most cases these costs were estimed to be marginal (i.e. $0 to $12,000 per year) at 10 per cent or less of projected fuel savings. The only exception to this rule was the proposed wood boiler at the Corner Brook Hospital, where these costs were projected to be $46,900 per year or 24 per cent of projected fuel savings.

4.2.3 Total Savings Potential

(a) Fuel Savings

The net savings potential of biomass conversion projects is equal to net fuel savings less the capital and extra operation and maintenance costs associated with the conversion (Table 7). The fuel saving impact of existing plants on the provincial economy is a reduction of oil imports by slightly over $11 million annually as indicated in Table 7. Of this total, $9.4 million is realized in energy savings and $1.6 million is used to purchase biomass fuel produced by local industry.

Table 7. Biomass Fuel Savings

Facilities	Biomass per year (Tonnes)	Estimated Annual Biomass Cost	Estimated Value of Oil Displaced	Estimated Annual Fuel Savings
Abitibi-Price	33,000*	$990,000	$1,536,150	$ 546,150
Grand Falls	46,000**	0	2,141,300	2,449,314
Abitibi-Price Stephenville	70,000*	0	3,258,500	258,500
Corner Brook Pulp and Paper	65,000**	0	3,025,750	3,025,750
NF. Hardwoods Clarenville	4,000*	134,000	192,800	58,800
NF. Hardwoods St. John's	550**	0	26,510	26,510
Superior Logging	2,300**	0	132,250	132,250
Gander Hospital	3,000*	103,500	148,500	45,000
Eastern Community College	480*	18,240	26,095	7,855
Corner Brook Hospital	10,000*	350,000	538,824	188,824
Other Facilities	327*	8,175	16,350	8,175
	204**	0	10,200	10,200
TOTAL	237,650	$1,732,350	$11,191,380	$9,459,030

* Woodchips or purchased sawmill residue.

** Waste utilized from own operations.

Sources: Department of Energy, Economic Evaluation of Selected Woodfuel Projects, 1986.

Oil and biomass costs used in these estimates were based on actual prices quoted in telephone interviews with a number of facility operators.

The economic evaluation study carried out by the Department of Mines and Energy (1986) examined eleven existing and proposed biomass fuel plants. The total capital costs of these plants was estimated at $7.5 million. The total wood burning capacity was 45,500 tonnes per year or 900,000 tonnes over their estimated twenty-year life cycle. The total net present values of these plants was $53 million assuming a 10 per cent discount rate[2] and a residual value of $0 for plant and equipment after the twenty years. A unit net present value is $5.89 per tonne of biomass potentially consumed in these plants over their life cycle.

Assuming that a net present value of the biomass energy industry was to remain constant at $ 5.89 per tonne, at the current level of consumption of approximately 240,000 tonnes (Table 7), the net present value of the industry over a twenty-year period is potentially as high as $28 million.

4.3 Savings Due to Residential Fuelwood

A recent study estimated that there were 65,451 wood-burning households in the province burning approximately 820,000 solid cubic meters (M^3) of fuelwood annually (Northland Associates, 1984). This total is broken down as follows:

Hardwood	179,000 M^3
Softwood	597,000 M^3
Scrapwood	44,000 M^3

Of this volume 77% was estimated to have been cut by householders themselves, while most of the remainder was purchased from commercial fuelwood suppliers.

2 A 10 percent discount rate was used because it represented the average borrowing costs of the provincial government.

While the study did not attempt to determine the costs to householders associated with cutting their own wood (eg. gas and equipment costs, etc.), an estimate was made of the average prices paid for purchased wood. These prices were :

Hardwood	\$27.96 per M^3
Softwood	\$21.61 per M^3
Scrapwood	\$11.31 per M^3

Given the lack of available data on the costs associated with self-procured fuelwood, these commercial prices are used here to calculate the economic value of all domestic fuelwood consumption. An assumption is that these prices reflect the average labour value plus expenses involved for people cutting their own wood. Given the substantial labour, fuel, and equipment needed to procure firewood, these prices are considered a fairly reliable indicator.

Table 8 provides a summary of the economic value of residential fuelwood consumption. Given the lack of more recent data, these values are based on 1983 consumption levels and prices. As shown, the total value of residential consumption in 1983 is estimated at approximately \$18.4 million.

Assuming constant levels of fuelwood consumption and average annual inflation of 5% since 1983, the 1988 value of residential fuelwood consumption is estimated at \$23.5 million. In terms of oil-equivalent value, 1 M^3 of round fuelwood is equivalent to approximately 128 liters of No. 2 furnace oil. Based on this displacement capacity, fuelwood consumption of 820,000 M^3 is equivalent to approximately 105 million liters of furnace oil. At the 1988 residential retail price of approximately 32 cents per liter for furnace oil, the oil-equivalent value of this level of fuelwood consumption is approximately \$ 33.6 million. With fuelwood costs estimated at \$23.5 million, a net cost

saving of approximately $ 10 million results due to residential wood-burning in the province.

Table 8. Value of Residential Fuelwood Consumption in 1983

Type	Quantity M^3 (solid)	Value per M^3	Value Total
Hardwood	179,000 M^3	$27.96	$ 5,004,840
Softwood	579,000 M^3	$21.61	$12,901,170
Scrapwood	44,000 M^3	$11.31	$ 497,640
	820,000 M^3		$18,403,650

4.4 Employment Impact

4.4.1 Construction

The initial economic benefit realized by the biomass energy industry is the employment generated in the construction and start-up of new industrial-burning facilities. A review of the literature on individual conversion projects has indicated a fairly consistent ratio of 1 person-year of construction labour input for every $80,000 to $100,000 of capital costs. At a total capital cost of approximately $3.8 million for existing conversion projects, this ratio indicates a realized employment benefit of 33 to 41 person-years in the construction and start-up of these plants.

4.4.2 Plant Operations

A survey of existing wood-burning plants has shown that the extra labour required to operate the plants after their conversion from oil-fired facilities is negligible. In some proposed conversion projects the employment effect in in-plant operations would actually be negative, for example in the proposed conversion of Gander Airport and Canadian Forces Bases to biomass (Shawmont NF Ltd., March 1987). In that project up to four in-plant jobs could potentially be lost as one centralized plant is planned to take over the function currently served by two existing oil-fired plants.

4.4.3 Supply of Biomass

Industrial biomass fuel in Newfoundland comes basically in two forms. The first is wood residues, primarily bark from the pulpwood debarking operations at the three paper mills and to a lesser extent sawmill waste. The second is woodchips from the harvesting and roadside chipping operations of the paper companies and independent contractors. Residential fuelwood comes mainly in the form of roundwood and to a lesser extent from scrapwood such as sawmill slabs. The following discussion examines the employment impact of each of these supply sources.

(a) Wood Residues

The burning of pulpwood bark at the three papermills is by far the major source of biomass fuel in the province (i.e. 180,000 tonnes per year). As this bark is produced as a waste by-product at the papermills and must be burned as a means of disposal, its use as an energy source does not generate jobs that would not otherwise exist.

Utilization of sawmill residue for energy production takes place primarily at the Grand Falls papermill, which purchases a supply from sawmillers in Central and Eastern Newfoundland. Sawmill residue is generally a mixture of bark from debarking operations, sawdust, and occasionally woodchips from unbarked slabs. Planer shavings are not usually used for fuel as they have a greater value as raw material for paper production.

Interviews with sawmill operators have indicated that the only significant employment impact directly derived from residue sales is in its transportation to the papermill in tractor trailer trucks.

Occasionally, some labour is employed to chip unbarked slabs. However, because this is not economically feasible, the employment impact is minimal. Other activities, such as the loading of biomass into trucks, are incidental to normal sawmill operations and require minimal labour input.

The sale of sawmill residues to the Grand Falls papermill takes place generally from mills in the Lewisporte, Glenwood, and Glovertown areas. The residues are typically trucked in tractor trailers with a capacity of about 33 tonnes. With 14,000 tonnes of waste being purchased annually from sawmill operators, about 425 truckloads are delivered to the mill. The direct employment impact of this trucking activity is about 2,500 person-hours or the equivalent of 0.0045 person-weeks per tonne.

(b) Fuel Woodchips

The primary users of roadside-produced woodchip biomass at present include the Gander Hospital, Abitibi-Price in

Grand Falls, Newfoundland Hardwoods in Clarenville, the Vocational School in Clarenville and the Corner Brook Hospital. Within the next few months the hospital at Grand Falls is due to come on stream. Abitibi-Price burns woodchips along with bark and the sawmill residues it purchases. Last year the company burned approximately 19,000 tonnes of hardwood chips produced from its own harvesting operations. Burning capacity in the other existing operations amounts to approximately 9,000 tonnes. The total capacity of the Grand Falls and Corner Brook hospitals will be about 14,000 tonnes. Assuming Abitibi-Price's consumption of fuel chips remains constant at 19,000 and the other users operate at capacity, the consumption potential for roadside-produced chips is estimated at 42,000 tonnes for next year.

Employment in the production of fuel woodchips is generated in harvesting, roadside chipping, and trucking activities, usually within integrated operations in which sawlogs and/or pulpwood are also being produced. The chips are usually produced from hardwood species such as birch and aspen, and from softwood trees that are unmarketable as sawlogs or pulpwood.

Discussions with logging operators revealed that normal production per person-day in skidder harvesting operations is about 7.2 M^3 of timber from the stump to roadside, taking into account foremen's time and normal downtime. Assuming a conversion factor of 554 kg of woodchips per M^3 the harvesting component of fuel chip production is estimated to have an employment impact of 0.20 person-days or 0.04 person weeks per tonne.

Employment is generated in the chipping operation itself and in the delivery of the chips. The chippers, which

can be run by one person, have an output capability of 8-10 tonnes per hour (personal communication: Norm Jackson, George Jackson and Sons, April, 1988). Allowing for a liberal amount of time for maintenance work, this figure translates into an estimated labour input of 0.015 person-days or 0.003 person-weeks per tonne for chipper operation.

As with the chipper operation, woodchip transportation requires relatively little labour input. Trucking distances are normally only a few kilometers. Using a trucking capability of 3 tonnes per hour (i.e. based on a 2-hour return trip for a single-axle truck carrying 6 tonnes) the estimated labour input required for transportation is estimated at 0.0083 person-weeks per tonne of fuel chips.

(c) Residential Fuelwood

Approximately 23 percent of residential fuelwood in the province is supplied by commercial operators (Northland Associates, 1984). Productivity in the commercial fuelwood industry is assumed to be similar to the fuel woodchip industry discussed peviously, where the employment ratios for harvesting and transportation were estimated at 0.04 person-weeks and 0.0083 person-weeks per tonne respectively. The equivalent employment ratios for residential fuelwood supply are 0.033 and 0.0068 per M^3.

4.4.4 Total Current Employment

Employment generated in the biomass energy industry takes place primarily in the construction of new wood-burning facilities and in the supply of biomass fuel. As cited

earlier, the construction of existing facilities has created in the range of 34 to 43 person-years of temporary employment over the past few years. The current estimated annual employment impact from operation of biomass suppliers is 2,218 person-weeks or 44 person-years (Table 9). The estimated employment in the commercial supply of residential fuelwood is 121 person-years (Table 10).

4.5 Income Impact

The employment income due to the use of biomass energy instead of oil is calculated based on an estimated industry wage rate of $9 per hour or $360 per week[3]. Based on the estimated 2,218 person-weeks of employment, an annual employment income is $798,480. For the commercial fuelwood industry the estimated 6,054 person-weeks of employment would indicate an annual employment income of $2,179,440 based on a similar wage rate.

4.6 Summary and Conclusions

This chapter has provided estimates of the current and potential economic impacts generated by biomass energy use in industrial and institutional facilities and by residential fuelwood consumption in Newfoundland and Labrador. These estimates do not account for corresponding losses due to reduced sales in the fuel oil distribution business. However, these losses are considered negligible due to the fact that the quantity of oil displaced is not significant in terms of overall consumption in the province. In fact, biomass and fuelwood energy combined are estimated to comprise a mere 5.7 percent of the total energy consumed in the province and only 8.9 percent of the oil energy consumed (Northland, 1984). Subsequently, employment losses would be marginal in relation to the gains possible in the biomass supply industry.

3 Interviews with logging contractors.

Table 9. Employment in the Biomass Supply Industry

Activity	Annual Consumption (tonnes)	Employment Ratio (person-weeks per tonne)	Annual Employment Impact (person-weeks)
Pulpwood Bark	180,000	0	0
Sawmill Residue	14,000		
Trucking		0.0045	63
Fuel Chips	42,000		
Harvesting		0.0400	1,680
Chipping		0.0030	126
Trucking		0.0083	349
TOTAL IMPACT	**236,000**		**2,218**
			(44 person-years)

Table 10. Employment in the Residential Fuelwood Supply Industry

Activity	Annual Consumption (M^3)	Employment Ratio (person-weeks per M^3)	Annual Employment Impact (person-weeks)
Roundwood	144,600		
Harvesting		0.0330	4,772
Trucking		0.0068	983
Scrapwood	44,000		
Trucking		0.0068	299
TOTAL IMPACT	**188,600**		**6,054**
			(121 person-years)

Table 11 provides a summary of estimated economic impacts derived from the use of forest biomass and residential fuelwood for energy generation in the province.

Table 11. Summary of Economic Impacts

A. Biomass Energy Use

Indicator	Current Impact (@ 236,000 t)
(1) Value of displaced oil imports	$11.1 million
(2) Value of biomass	$ 1.7 million
(3) Energy savings	$ 9.4 million
(4) Capital expenditures on plants	$ 3.3 million
(5) Construction employment	33-41 person-years
(6) Annual employment in biomass supply	44 person-years
(7) Annual employment income	$ 0.80 million
(8) Value of sawmill waste used	$ 0.35 million

B. Residential Fuelwood Use

Indicator	Current Impact (@ 820,000 M^3)
(1) Value of fuelwood consumption	$23.5 million
(2) Oil-equivalent value of fuelwood consumption	$33.6 million
(3) Energy savings	$10.0 million
(4) Value of commercial fuelwood sales	$ 3.8 million
(5) Annual employment in commercial fuelwood industry	121 person-years
(6) Annual employment income in commercial fuelwood industry	$ 2.2 million

At present, considerable biomass energy generation in the province results from the utilization of waste, primarily pulpwood bark and to a lesser extent sawmill residues. This practice results in substantial savings to the papermills and also provides some additional revenues to sawmill operators. The employment impact however is negligible given that these are waste by-products. In contrast, woodchip biomass is purposely produced for energy use. Hence, while woodchips do not have as large a saving impact, their use use does result in significant employment in harvesting and delivery. As shown in Table 8, current employment in the biomass supply industry is estimated at 44 person-years, of which 97 percent results from the production and transportation of fuel chips.

In addition to the positive impact of jobs, biomass use at current capacity levels has an import-replacement effect in the provincial economy of approximately $11 million at current oil prices. If oil prices returned to their previous high levels this effect would be even higher. Of this $11 million, over $9 million is realized in direct savings to energy users while the remainder is realized in the biomass supply industry.

Provincial residential fuelwood consumption is estimated at approximately 820,000 m^3, with a value of approximately $23.5 million. Energy savings realized by burning wood instead of oil is estimated at $ 10 million. Most of this consumption, or about $19.7 million, is wood cut by householders themselves. The remainder, $3.8 million is the value of the commercial fuelwood supply. The commercial industry provides approximately 121 person-years of employment and up to $2.2 million in employment income.

5.0 FUTURE OPPORTUNITIES FOR WOODFUEL INDUSTRY DEVELOPMENT

5.1 Background

In the last ten years, major advances have been realized in promoting the status and profile of forest biomass utilization in this province. Numerous medium scale woodburning installations are presently operational and several others are recommended based on recent feasibility studies. This progressive climate bodes well for the future of biomass in Newfoundland. As new areas of opportunity are addressed, biomass use will increase thereby reducing our collective reliance on traditional energy sources.

5.2 Future Opportunities By Sector

a) Residential Sector

As discussed earlier, domestic fuelwood consumption has grown remarkably in this province since the mid 1970s. While the recent decline in oil prices has affected consumption somewhat, this alternate energy resource will likely continue to maintain a high profile in Newfoundland households. One potential attraction to the domestic user is the future development of fuelwood yards which would provide a major convenience to woodburning households as a retail outlet precluding the need for the present capital outlays (eg. saws, ATVs, sleds, etc.) presently required for fuelwood procurement.

A greater focus on the management of the forest resource vis-a-vis domestic cutting would help ensure a long term biomass supply as well as incorporate the needs and objectives of other land users. The province of New Brunswick maintains carefully regulated control of its fuelwood resource through equitable

stumpage policies, land use allocation and other measures. These could serve as guidelines to more effective biomass resource management in this province.

b) **Forest Industry Sector**

The forest industry sector presently consumes the lion's share of woodchips and bark residue produced in this province. However, the three newsprint mills still hold much potential for increased biomass consumption. One point of consideration is the increased consumption capacity possible with the upgrading of the boiler systems at both the Grand Falls and Corner Brook facilities. Both mills have experience in woodchip burning which could be significantly expanded by replacing the current boilers with units designed for woodchip utilization. Fuel supply remains a prime concern of the Stephenville operation and its resolution would establish another likely prospect for medium scale woodchip conversion.

c) **Commercial Sector**

Owing to their widely disseminated nature, players in the commercial sector pose a very great potential for expanding the biomass industry in this province. There exists a plethora of small and medium scale businesses throughout Newfoundland, of which many are serious candidates for fuelwood conversion. Earlier discussion presented several examples of current woodburning operations in a wide range of business disciplines. With further proliferation of similar conversion initiatives, a province-wide network of commercial biomass users is indeed possible.

d) Public Sector

Recent successes have reinforced the merits of woodchip conversion projects in the public sector. Experience gained from developments such as the James Paton Memorial Hospital is invaluable to future conversion initiatives at similar institutions. A wealth of largely untapped potential exists within the public sector given the network of hospitals, colleges, government buildings, etc. occurring throughout the province.

5.3 Government Programs and Policies

The government sector remains a necessary participant for further development of this industry. Both the federal and provincial governments will need to sustain their contributions in further areas of research, development, demonstration project funding, program administration, and information transfer.

Endeavors outlined below warrant consideration for government support as likely steps to assist the expansion of the forest biomass industry in this province:

- Further research to assess the potential of integrated harvesting
- Studies to determine the practicality and feasibility of introducing a wood densification industry in this province, especially in areas far removed from localized wood supplies
- Residential woodchip burning received an encouraging consumer response as a result of a CREDA study in 1984 (discussed earlier). Further research to determine the practicality of this endeavor should address the need for an acceptable supply/demand regime and also the availability of approved woodchip burning technology for the residential sector
- Economic and marketing studies should be carried out for possible introduction of fuelwood yards in areas of wood

fibre shortage. Targeting the residential sector, this distribution service would increase the ease of obtaining forest biomass for energy. A forest products marketing board should also be considered to regulate the supply of wood to the retail outlet from forestry contractors

- Labrador is an area due greater consideration for government support toward increased forest biomass utilization. The colder climate is accompanied by a greater consumption of furnace oil and stove oil relative to the island (increases of 44% and 47% respectively) at a higher fuel price level (eg. stove oil: 16%) (Newfoundland Statistics Agency, 1986)

- Technical demonstrations of feasible initiatives in areas of district heating, co-generation and electricity generation are also prospective candidates for government support which would assist the expansion of the forest biomass industry

Ongoing research within the Canadian Forestry Service has resulted in the evolution of two computer simulation models which have application potential in the biomass industry. The first model originated in British Columbia and allows the calculation of residual biomass (in total tonnes by tree component) on a site following conventional harvesting. The second is the FORCYTE model which is capable of assessing the impact of forest management systems on ecosystems. FORCYTE also originated in British Columbia but is presently being calibrated for western Newfoundland.

5.4 Potential Economic Benefits

The purpose of this section is to estimate the potential socio-economic benefits of expanded forest biomass energy use in the province, based on the development of proposed new conversion projects.[4] Two future consumption levels are assumed for this estimation:

4 These include: Grand Falls Hospital @ 4000 t, new boilers at the 3 paper mills @ 100,000 t each, Nfld. Hydro's plant at Roddickton @ 60,000 t, Gander Airport @ 10,000 t, Erco @ 15,000 t, F.P.I. at Catalina @ 9,000 t, F.P.I. at Harbour Breton @ 6,000 t, Wooddale Tree Nursery @ 3,000 t, plus a number of smaller facilities.

(1) A level of 450,000 tonnes or, an increase of 215,000 tonnes over current consumption, representing an expansion of about half of the total proposed.

(2) A level of 665,000 tonnes or, an increase of 430,000 tonnes, representing an expansion involving all proposed projects.

With the already high consumption in the residential fuelwood market, no evidence exists that this sector will grow substantially above current levels.

5.4.1 Construction Activity

A study of biomass energy use (Department of Energy, 1986) proposed that $62 million be invested in biomass energy projects over a six year period. At an average expenditure of $10 million per year, a sizable impact would be felt in the construction industry.

5.4.2 Energy Savings and Import Replacement Potential

As indicated in Chapter 4, current biomass consumption has an oil-equivalent value of approximately $11 million of which $9.4 million is realized in energy savings to the users and $1.6 million is generated in the biomass supply industry. If only half the proposed expansion of biomass occurred, the value of the industry would grow to $22.5 million in displaced oil imports, of which $13.3 million would be realized in energy savings and $9.1 would be realized in the biomass supply industry (Table 12). If the industry expanded fully as proposed, the oil displacement value would be $33.9 million, of which $17.2 million would be realized in energy savings and $16.7 would be realized in the biomass supply industry.

TABLE 12. Biomass Fuel Savings*

Consumption	Biomass per year (Tonnes)	Estimated Annual Biomass Cost	Estimated Value of Oil Displaced	Estimated Annual Fuel Savings
Current	234,861	$ 1,603,915	$11,053,229	$ 9,449,314
With half proposed expansion	450,000	9,128,915	22,476,179	13,347,264
With entire proposed expansion	665,000	16,653,915	33,899,129	17,245,214

* Assumes the following:

(i) Contant biomass costs for future facilities @ $35 per tonne.

(ii) Constant fuel oil costs @ 23¢ per liter.

(iii) Constant biomass oil-displacement capacity of 231 liters.

In the preceding chapter (Section 4.2.3), the net present value realized from investment in biomass energy plants was an estimated $5.89 per tonne of biomass over the average 20-year lifespan of plants. Assuming this value was to remain constant, an expansion of capacity to 450,000 tonnes would result in a total net present value of $58 million over the 20-year period. An expansion as proposed to the 665,000 tonne level would result in a net present value of $78.3 million.

5.4.3 Employment Potential

(a) Construction Employment

As mentioned above, the total capital costs associated with the construction and start-up of currently proposed biomass energy plants would be $62 million. Using the estimated ratio of 1 person-year of labour input for

every $80-$100 thousand of capital costs associated with these facilities (Section 4.3.1), an employment benefit of 620-775 person-years would result from total construction activity. Over a six-year period as recommended by the Department of Energy, the average impact would be 100-130 person-years of employment per year.

(b) Employment in Biomass Supply

Table 13 provides an estimate of employment levels in the biomass supply industry at potential future levels of consumption and assumes that employment ratios in the future will remain unchanged from those estimated for the current industry (Section 4.3.4).

As shown, if biomass consumption rises to 450,000 tonnes annually, the employment impact in the supply industry would potentially increase to 265 person-years. With a full expansion as proposed to 665,000 tonnes, the employment potential would be 483 person-years. Taking into account that much of this activity would be seasonal in nature, the benefits in terms of total people employed would be even larger.

5.4.4 Income Potential

At a consumption level of 450,000 tonnes the biomass industry would generate approximately $9.2 million in gross revenues and 13,196 person-weeks of employment annually (Table 12 and 13). At an estimated average wage rate of $9 per hour, the annual employment income in the industry would be approximately $4.8 million. At a consumption level of 665,000 tonnes, gross revenues would

be approximately $16.7 million, employment would be 24,162 person-weeks, and employment income would be $8.7 million.

TABLE 13. Potential Employment Impact of Future Biomass Energy Use

Activity	Annual Consumption (tonnes)	Employment Ratio (person-weeks/tonnes)	Annual Employment Impact (person-weeks)
(1) @ 450,00 tonnes			
Pulpwood Bark Production	180,000	0	0
Sawmill Residue Production	14,000	0	0
Trucking	0	0.0045	63
Fuel Chips Harvesting	256,000	0.04	10,240
Chipping	0	0.003	768
Trucking	0	0.0083	2,125
TOTAL IMPACT	**450,000**		**13,196** (264 person-years)
(2) @ 665,000 tonnes			
Pulpwood Bark Production	180,000	0	0
Sawmill Residue Production	14,000	0	0
Trucking	0	0.0045	63
Fuel Chips Harvesting	471,000	0.04	18,840
Chipping	0	0.003	1,413
Trucking	0	0.0083	3,909
TOTAL IMPACT	**665,000**		**24,162** (483 person-years)

5.4.5 Summary of Potential Economic Impacts

Table 14 provides a summary of the potential future economic benefits that would accrue with expansion of biomass energy use in the province.

With limited potential for the utilization of additional residue fuel, an increase in biomass fuel requirements would have to be met mostly in the form of woodchips. Assuming residue consumption remained at present levels, an increase of biomass requirements to 450,000 tonnes would result in the creation of an additional 220 person-years of employment annually. An increase to 665,000 tonnes would create an additional 439 person-years annually.

Significant employment would also be generated in the construction and start-up of burning facilities. If all proposed facilities were established over the next six years, the employment effect would be 100-130 person-years annually.

In terms of import replacement, an increase of biomass use to 450,000 tonnes would result in an oil-displacement capacity valued at approximately $22.5 million, assuming constant prices for oil biomass. Of this amount, approximately $13.3 million will be realized in direct energy savings and $9.1 million would be generated in tha supply industry. At a usage level of 665,000 tonnes the oil-displacement value would rise to approximately $33.9 million, of which $17.2 million would be realized in savings and $16.7 million in the supply industry.

TABLE 14. Summary of Future Economic Impacts

Indicator	Current Impact (@ 236,000 t)	Potential Impact (@ 450,000 t)	Potential Impact (@ 665,000 t)
Value of displaced oil	$11.1 million	$22.5 million	$33.9 million
Value of biomass	$ 1.6 million	$ 9.1 million	$16.7 million
Energy savings	$ 9.4 million	$13.3 million	$17.2 million
Capital expenditures on plants	$ 3.3 million	N/A	$62.0 million
Construction employment	33-41 person-yrs	N/A	620-775 person-yrs
Annual employment in biomass supply	44 person-yrs	264 person-yrs	483 person-yrs
Annual employment income	$ 0.8 million	$4.8 million	$8.7 million
Value of sawmill waste used	$ 0.35 million	$0.35 million	$0.35 million

As shown, the economic benefits to the province from increased biomass energy use are substantial, particularly in energy savings and retention of income. As of yet the employment benefit is relatively small. However, if the industry expands to potential levels, substantial numbers of jobs could be created. This factor takes on greater importance given that the jobs would be created largely in rural areas, where employment and income opportunities are fewer. At the present time, low oil prices have somewhat reduced the economic viability of proposed conversion projects and their future development looks uncertain. However, the oil market has proven very volatile in the past and rising oil costs in the not-to-distant future are not unlikely.

5.5 Potential Forestry Benefits

From a forest industry perspective, an expanded biomass utilization program in this province would provide a series of positive impacts on forest operations. Non-merchantable timber from dead and dying "junk" stands (i.e. resulting from storms, fires, insects or disease) can be removed and utilized as energy fuel. Ongoing forest inventories have enabled the Provincial Department of Forestry to estimate the area of "softwood scrub" (i.e. stands having fiber yield of less than 35 m^3/ha over the rotation) to be 2.1 million hectares. This figure is a conservative estimate which does not include major sections of forest management units 3, 14 and 17, expected areas of softwood scrub occurrence (Figure 2). At a yield rate of 50% (i.e. 17.5 m^3/ha) this would represent 36,750,000 m^3 (approximately 10 million cords). These stands as well as currently underutilized species such as larch, provide biomass upon removal; also the cleared sites are more suitable for replanting. This harvesting therefore not only provides a supplementary energy source but also serves to "free up" previously non-productive stands for subsequent forest management. One attractive advantage is that the ensuing silviculture costs on the cleared sites could be offset by the fuel cost savings generated from oil displacement. Further studies may provide a cost/benefit relationship to this approach. Additional forestry benefits associated with cleaning up waste wood include a reduction in forest fire hazard, reduction of tree diseases and insect damage, improved forest aesthetics and improved wildlife habitat (Newfoundland Department of Energy, 1987).

With a concerted attendance to the dangers of site nutrient depletion, it is indeed possible to engender a more complete forest stand utilization. Traditional forest products (eg. pulpwood, sawlogs) combined with a more prominent role exercised

by forest biomass will allow a greater return per unit forest area to the sectors involved (eg. forest industry, residential, etc.).

5.6 Summary

Latitude exists within the various regions of this province to allow the growth and expansion of the local forest biomass industry. Areas for future consideration and possible application have been outlined as they relate to the various players in this province. As indicated, continued government support is required to assist the various sector participants in bringing their endeavors to fruition.

6.0 POSSIBLE CONSTRAINTS TO WOODFUEL INDUSTRY EXPANSION

6.1 Background

In order to effectively appraise the potential benefits of forest biomass as an energy source, an evaluation of certain constraints and limitations of this resource is required, especially as it competes with conventional energy types. Conventional fuels are "marketed according to specific standards that guarantee final uniformity in product composition" (Passmore and Ensyn, 1987). The end-user thus is able to rely on a proven product handling and distribution system. Biomass on the other hand, possesses several undesirable features which serve to dampen its appeal such as non-uniformity of fuel particle size, low energy density, high moisture content and frequent high impurity levels. These characteristics dictate the need for certain engineering and design considerations to optimize the performance of the various players within this industry. An obvious example has been the move to woodchips rather than roundwood as a biomass fuel type for medium scale installations in the pertinent sectors. This preliminary comminution facilitates more efficient biomass transport, storage and handling as opposed to roundwood.

6.2 Wood Supply

Wood supply remains the single overriding factor influencing the recommendation of a facility for biomass consumption. The island portion of the province sustains approximately 2.9 million hectares (204 million green tonnes) of productive forest land and 2.1 million hectares (100 million green tonnes) of softwood scrub. In addition the hardwood component accounts for 33 million green tonnes of biomass (Buggie, 1986). Though vast, this resource must be considered within the context of economic

accessibility, prior allocation for other uses (eg. hardwood logs) and other constraints. Regional biomass studies serve to determine the approximate amount of wood available for specific projects or a regional series of projects. The lack of an economic biomass supply at an acceptably close proximity to both the ERCO operation at Long Harbour and the Abitibi-Price mill at Stephenville influenced the decision not to proceed with the conversion of these outlets for biomass consumption. Both the Avalon and Burin Peninsulas are especially noteworthy with respect to their dearth of forest biomass, a factor which contributes to preclude medium-scale conversion initiatives on a regional scale.

The lack of a reliable biomass supply has restricted the development of a residential woodchip burning industry in this province. Due to the wide dispersion of a low number of woodchip burning households throughout Newfoundland a sufficient fuel demand does not exist in any single region to economically sustain the necessary woodchip supply. An increase in localized woodchip consumption is necessary to justify the evolution of regional domestic woodchip supply centers.

Domestic fuelwood procurement has resulted in frequent cases of highgrading, indiscriminate cutting and an overall drain on the province's forest resources. Such incidents will undoubtedly be reflected in the declining quality and quantity of Newfoundland's forests. However, the total consumption estimates reported for each region of the province should not be considered to reflect the actual drain on Annual Allowable Cut (AAC) by biomass harvesting. Much of the wood consumed would have been harvested from sites not included for consideration as part of the AAC (i.e. scrub forest, logging residues, etc.). The Provincial Forest Management Unit #1 has designated six productive forest management zones which are complemented by the

lower productivity sites. These two site categories are considered separately for potential impact of biomass cutting on the Annual Allowable Cut.

6.3 Economics

Economic factors are a major concern in assessing the potential of biomass energy projects. As discussed in Chapter 4, the major economic influences on the viability of biomass energy use are the relative costs of fuel oil and biomass and the capital costs of constructing new biomass energy facilities. In the past two years the previous trend of rapidly escalating oil prices has reversed and industrial oil price levels in the province have now declined to approximately the same as they were in 1981 (Figure 3). This price drop has resulted in substantially lower savings potential than was previously possible through biomass energy consumption. As a result the viability of new biomass energy projects has been reduced.

The influence of fuel oil prices on the viability of biomass energy use is illustrated in Table 5 which shows potential energy savings from biomass use at a range of fuel price levels. For example, at a price of 35 cents per liter, which approximates actual levels of a couple years ago, the savings potential of biomass at $35 per tonne was about $46 for every tonne used. In contrast, the savings potential with oil at 23 cents per liter is only $18 per tonne. Relating this difference to a facility with a capacity, for example, of 5000 tonnes of biomass per year, the cost saving would be $90,000 at the lower oil price as compared to $230,000 at the higher price.

The high capital costs of installing biomass handling and burning equipment is also a major influencing factor on the feasibility of conversion projects, especially with the current

low oil prices. As biomass energy savings decline with falling oil prices, capital costs as a proportion of overall costs rise and thus reduce the feasibility of conversion projects. Another constraint is the large up-front investments necessary with biomass conversion projects. Regardless of the possible savings over the long-term, individual owners have difficulty financing such large ventures. For example, the estimated $32 million cost for boiler retrofit at the Corner Brook paper mill has been a major deterrent to that proposed project.

6.4 Environmental Concerns

Environmental concerns for the expansion of the woodfuel industry relate to two primary areas: undesirable air emissions and on-site disturbance. In the past air pollution problems have existed at both the Corner Brook and Grand Falls newsprint mills due to the type of equipment involved in the wood burning process. The Corner Brook mill was forced to discontinue woodchip burning as a result of unacceptably high levels of particulate matter being produced. With the aforementioned equipment retrofits, both newsprint mills would be able to avoid this emissions problem.

Field studies have shown that whole tree harvesting poses no greater threat to the physical stability of the forest site than do conventional harvesting practices. These studies defined stability in terms of disturbances to the vegetation and to the upper soil horizons(Northland Associates Limited, 1981).

Site nutrient depletion associated with whole tree harvesting remains an ongoing concern of forest managers and other groups involved in the forest industry. Current research directed at resolving this uncertainty is being carried out by various organizations (eg. Canadian Forestry Service - FORCYTE model).

Results of work carried out in Sweden on this subject suggest that nutrient depletion will not pose a major threat to site quality/productivity (Buggie, 1988).

6.5 Technology

As with any new and relatively untested area of development the rate of progress is dependent on the capacity of available technology. In recent years, the woodfuel industry has become increasingly competitive vis-a-vis equipment suppliers. As a result, the end-user retains a wider array of options. Nevertheless, each facility is limited by the type of storage, handling and processing technology available. The Eastern Community College at Clarenville has experienced design difficulties with its handling equipment which have compromised its performance efficiency. As the biomass industry expands in this province, the incidence of such limitations should be mitigated owing to the widening experience and awareness of the players involved.

Wood heating systems are subject to the scrutiny of various regulating agencies (eg. Canadian Standards Association). As a result, strict adherence to an array of codes, regulations and standards imposed by federal, provincial and municipal bodies is a requisite for membership in the woodburning community. This fact poses an obvious constraint to prospective woodburners as was witnessed by participants in the Domestic Woodchip Heating Project (under CREDA sponsorship) in 1984. In this case the Firefly woodchip burning units involved did not qualify for CSA approval and were subsequently deemed unacceptable for coverage by several insurance firms in the province. Understandably this problem led to the termination of many household's woodchip burning activities.

6.6 Government Policy

A final potentially constraining factor relates to the future role of the various government bodies. Both levels of government (i.e. federal and provincial) are largely responsible for the current level of development that has been achieved in the province's biomass fuel industry. As the industry continues to mature and more technical demonstrations come onstream, government focus will likely shift from project demonstrations to greater research and development. Both EMR (federal) and the Department of Energy (provincial) will become increasingly selective as to which demonstration projects meet with their approval. The Forest Products and Development Division of the Provincial Department of Forestry has also expressed an interest in altering its emphasis from conventional whole tree harvesting/chipping trials to the area of integrated harvesting. This collective shift in government policy could serve as a constraint to the woodburning industry if it prevents further development of existing areas of the biomass industry. This problem appears unlikely however, reflecting rather the natural transition in the life cycle of an emerging industry as technologies, expertise and attitudes become more established.

One area of tentative concern deals with the future status of government incentive programs designed to encourage biomass utilization. Certain programs (eg. CREDA, COSP) have proven very successful in accelerating the rate of biomass consumption throughout various sectors of the Newfoundland economy. A complete or partial withdrawal of these programs without comparable replacement would undoubtedly serve to retard the development of a forest biomass industry in this province.

6.7 Summary

The emergence and development of the forest biomass industry in this province has and will continue to occur within the constraints imposed by a variety of influences. Wood supply and the cost of competitive fuel types remain as key considerations for any prospective conversion project. Additional areas of potential constraint include environmental, technology and government policy. These factors will greatly influence the practicality and feasibility of ongoing and future projects.

7.0 CONCLUSIONS

The oil embargo by certain OPEC member countries in 1973 prompted a greater global awareness in alternate fuels that continues today. Since that time, forest biomass has garnered a very established role as a source of fuel throughout Newfoundland. Traditionally used for heating and cooking in the residential sector, this resource has now been sought and adopted by a wide array of players in this province.

Government involvement has significantly aided the growth and maturity of the biomass industry in this province. Sponsorship of a diverse collection of biomass related projects by both the federal and provincial governments has succeeded in expanding the wood burning community. Certain endeavors have proven quite successful such as the Eastern Community College-Clarenville biomass conversion project, while others have not, for example the Abitibi-Price Inc., Bowater Newfoundland Ltd. - Integrated Harvesting Trials.

Newfoundland contains large reserves of forest biomass. However, as indicated earlier this resource must be considered on a per project basis to determine what is economical.

From a socio-economic perspective, the development of a local forest biomass industry offers a very significant benefit in terms of revenue retained and recirculated in Newfoundland rather than exported outside the country to purchase fossil fuels. Greater energy self-sufficiency remains a further incentive for increased biomass utilization.

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APPENDIX I

Approach and Methodology

The very nature and scope of this study have made necessary the review and compilation of numerous related studies into a single reference publication. This has required an in depth search of scientific reports, technical bulletins, feasibility studies, conference proceedings and project reviews pertinent to the provincial woodfuel industry. In addition information and views were sought from a myriad of persons involved in this area of development. The list below includes personnel contacted through interviews and/or telephone conversations.

Name	Organization
Dr. Grant Milne (Scientific Authority)	Canadian Forestry Service
Mr. William Alexander	Canadian Forestry Service
Mr. George Veitch	Canadian Forestry Service
Mr. Philip Graham	Newfoundland Department of Energy
Mr. John Drover	Newfoundland Department of Energy
Mr. David Bazeley	Newfoundland Department of Energy
Mr. Donald Peach	Newfoundland Department of Energy
Mr. Paul Duffett	Energy, Mines and Resources Canada
Mr. Lloyd Walker	Wallken Enterprises Ltd., St. John's
Mr. Stephen Benson	Woodland Nurseries, St. John's
Mr. Merlin Mills	Newfoundland Hardwoods Ltd., St. John's, Clarenville
Mr. Maurice Mills	Acres International Ltd., St. John's
Mr. Dieter Hohoff	Fishery Products International Ltd., St. John's
Mr. Barnett	ERCO Industries, Long Harbour
Mr. Kevin Wareham	Kevin Wareham Ltd., Arnolds Cove
Mr. Gerald Saunders	Natural Enterprises Ltd., Butts Pond
Mr. Peter Lush	James Paton Memorial Hospital,Gander

Name	Organization
NA	Adams Construction Ltd., Bishop Falls
Mr. Gerald Prince	Central Newfoundland Regional Health Center, Grand Falls
Mr. William Furey	Abitibi-Price Inc., Grand Falls
Mr. Harvey Taylor	Abitibi-Price Inc., Grand Falls
Mr. Maxwell Goudie	Superior Logging Ltd., Springdale
Mr. John Lloyd	John Lloyd Ltd., Baie Verte
Mr. Maxwell Penney	Eastern Community College, Clarenville
Mr. Roy Whelan	Western Woodworkers, Deer Lake
Mr. George van Koetsveld	Barony Produce, Cormack
Mr. David Murphy	Murphys Transport Ltd., Corner Brook
Mr. Maxwell Powell	Western Memorial Hospital, Corner Brook
Mr. George van Dusen	Corner Brook Pulp and Paper Ltd.
Mr. Douglas Kendrick	Corner Brook Pulp and Paper Ltd.
Mr. Neil Woolfrey	Glenwood Forest Products Ltd.
Mr. Gerald Smith	Abitibi-Price Inc., Stephenville
Mr. Ivan Downton	Newfoundland Department of Forestry
Mr. Allan Masters	Newfoundland Department of Forestry
Mr. George Ross	Newfoundland Department of Forestry
Mr. William Buggie	Newfoundland Department of Forestry
Mr. David Cheeks	Newfoundland Department of Forestry
Mr. Reginald Davis	Newfoundland Department of Forestry
Mr. Eric Saltor	Newfoundland Department of Forestry
Mr. T. Smart	Residential Chipburning, St. John's
Mr. A. Norris	Residential Chipburning, Clarenville
Mr. R. Carroll	Residential Chipburning, Gander
Mr. V. Dunn	Residential Chipburning, Gander
Mr. L. Little	Residential Chipburning, Appleton
Mr. H. Samson	Residential Chipburning, Gander
Mr. D. Borden	Residential Chipburning, Windsor
Mr. W. Sullivan	Residential Chipburning, Grand Falls

Name	Organization
Mr. R. Porter	Residential Chipburning, Grand Falls
Mr. J. Gallant	Residential Chipburning, Corner Brook
Mr. J. Peddle	Residential Chipburning, Corner Brook

APPENDIX II

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Calculation of Ratios
Capital Costs/Estimated Cash Flow Savings (1986)*
Selected Facilities

Project	Estimated Capital Cost	Estimated Cash-Flow Savings	Ratio
Gander Hospital	$ 995,000	$ 77,000	12.9/1
Nfld. Hardwoods	560,000	136,400	4.1/1
Eastern Community College	192,900	24,000	7.9/1
Corner Brook Hospital	1,015,000	147,200	6.9/1
Wooddale Nursery	440,000	71,600	6.1/1
Grand Falls Hospital	412,600	116,000	3.6/1
Stephenville District	800,000	70,000	11.4/1
F.P.I. Catalina	812,000	224,200	3.6/1
F.P.I. Harbour Breton	754,000	33,000	22.8/1

* Department of Energy, Economic Evaluation of Selected Woodfuel Conversion Projects, 1986.

APPENDIX III

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Conversion Factors

1 CORD	=	3.6 m^3 (stacked)
	=	2.4 m^3 (solid)
	=	2.0 tonnes
1 TERAJOULE	=	43 cords (approx.)
Kilo	=	10^3
Mega	=	10^6
Giga	=	10^9
Tera	=	10^{12}
Peta	=	10^{15}